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Vocal function exercises for normal voice: The effects of varying dosage

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Abstract

Purpose: This study examined the effect of varying dosage of vocal function exercise (VFE) home practice on attainment of pre-established maximum phonation time (MPT) goals in individuals with normal voice. High dosage VFE practice was expected to result in greatest MPT. The overarching goal of this study was to contribute to a VFE dosage-response curve, potentially including a point of observable toxicity.

Method: Twenty-eight females ages 18–25 with normal voice participated in this pre-post longitudinal group study. Participants were randomly assigned to one of three experimental groups and completed a six-week VFE protocol with practice twice daily. The low dosage group performed each exercise once, the traditional group twice, and the high dosage group four times. The primary outcome measure was MPT as performed on the fourth VFE using the prescribed semi-occluded vocal tract posture.

Result: No toxic effects were observed. MPT increased for all participants, with significant improvement for traditional and high dosage groups.

Conclusion: High dosage VFEs may yield more rapid improvement in MPT, however benefits must be weighed against the risk of increased attrition. Low dosage VFEs insufficiently improved MPT. Further research on dosage is warranted, and should include individuals with disordered voice.

Keywords

vocal function exercises; dosage; maximum phonation time; voice

Introduction

While many phase one trials demonstrate positive treatment effects for various interventions in speech-language pathology, most treatments currently employed have little to no information from phase two trials providing guidance on dose-response relationships (Roy, 2012). This issue is especially salient in the area of voice therapy, where dosing can mean

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Declaration of interest

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the difference between no effect, the ideal effect, and toxic or adverse effects as a result of exceeding a certain “vibration dose” (Roy, 2012; Titze, 1994). Vibration dose, as described by Titze (1994), refers to the vibration energy absorbed by the vocal folds, which is proportional to the frequency and amplitude of vibration. Adverse effects resulting from vibration overdose include overuse kinds of injuries such as oedema, erythema, laryngeal muscle strain and benign lesions as can be observed in people with heavy voice use who seek treatment for voice disorders.

Due to the potential for vibration-induced toxicity in the laryngeal system, a common voice therapy approach is to reduce overall acceleration and shearing forces (i.e. vocal load) on the vocal fold mucosa during phonation. Traditionally, vocal load has been reduced using information-based approaches such as vocal hygiene, but vocal load can also be reduced by exercise-based approaches that train the vocal mechanism in ways that increase the efficiency (and decrease the phonotrauma) of vibration (Titze, 2006). One such strategy is vocal function exercises (VFEs), a direct behavioural training approach that is hypothesised to strengthen and rebalance the laryngeal musculature and enhance the dynamic relationship among the three principle subsystems of voice: respiration, phonation and resonance (Stemple, Lee, D’Amico, & Pickup, 1994). The benefits attributed to the VFE programme are thought to be in part due to the use of a semi-occluded vocal tract posture, which is theorised to achieve greater vocal output while minimising vocal fold stress and physical effort (Croake, Andreatta, & Stemple, 2016).

While a total of 27 outcome studies have demonstrated VFEs to be effective in enhancing normal (Ellis & Beltyukova, 2011; Stemple et al., 1994), pathological (Berg, Hapner, Klein, & Johns, 2008; Gelfer & Van Dong, 2013; Gillivan-Murphy, Drinnan, O’Dwyer, Ridha, & Carding, 2006; Gorman, Weinrich, Lee, & Stemple, 2008; Jafari et al., 2017; Kaneko et al., 2015; Kapsner-Smith, Hunter, Kirkham, Cox, & Titze, 2015; Kumar, Sharma, Vir, & Panda, 2016; Lim, Kim, Kwon, & Park, 2009; Nguyen & Kenny, 2009; Pasa, Oates, & Dacakis, 2007; Patel, Pickering, Stemple, & Donohue, 2012; Pedrosa, Pontes, Pontes, Behlau, & Peccin, 2016; Radhakrishnan & Mathisen, 2016; Radhakrishnan & Scheidt, 2012; Roy et al., 2003; Roy et al., 2001; Sauder, Roy, Tanner, Houtz, & Smith, 2010; Sharma, De, Martin, & Pracy, 2009; Tanner, Sauder, Thibeault, Dromey, & Smith, 2010; Tay, Phyland, & Oates, 2012; Teixeira & Behlau, 2015; Ziegler, Verdolini Abbott, Johns, Klein, & Hapner, 2014), and well-trained voices (Guzman, Angulo, Munoz, & Mayerhoff, 2013; Sabol, Lee, & Stemple, 1995), little is known about the ideal dosage, or the dosage that yields the greatest benefit without causing damage (Roy, 2012). According to Stemple et al. (1994), the standard protocol for VFE home practice involves performing a set of four exercises, two times each, both morning and evening. However, without more information regarding the dosage-response relationship for VFEs, it is unknown whether this exercise schedule optimises treatment efficiency.

As in pharmacology, inaccurate dose and dosage of behavioural interventions can be more harmful than they are beneficial (Roy, 2012). Suboptimal levels of an intervention may lead to poorer outcomes, frustrate the client, and fail to resolve vocal issues, which may ultimately result in social withdrawal, occupational difficulty, and reduced quality of life (Roy, Stemple, Merrill, & Thomas, 2007; Verdolini & Ramig, 2001). Suboptimal dosage

may also make treatment as ineffective as no intervention at all if the client fails to attain any benefit or vocal improvement as a result of intervention (Roy, 2012). Conversely, excessive dosage may produce diminishing returns, have no additional effect, become harmful, and prompt heavier caseloads and poorer quality of care by increasing the burden on professionals (Baker, 2012; Roy, 2012). In both cases, suboptimal dosage does not result in optimal therapeutic outcomes and is therefore potentially wasteful of time, money and resources.

There are several obstacles to determining ideal dose and dosage for behavioural interventions such as VFEs. Central among these obstacles is failure to identify the active ingredient within the intervention (i.e. the precise agent responsible for physiologic change). Although it is postulated that the benefits of VFEs stem from strengthening, rebalancing, and coordinating the laryngeal musculature, this hypothesis currently remains an open question (Roy, 2012). Further confounding the ability to determine ideal therapy dosage are several other complications enumerated by Roy (2012) and Baker (2012).

First are challenges that correspond to our understanding of physiology as discussed by Roy (2012). The principles of exercise physiology and sensorimotor learning are primarily borrowed from knowledge of limb musculature, and only a superficial link exists between the musculature of the limbs and that of the larynx. Furthermore, voice therapy often operates non-linearly, meaning incremental adjustments in technique may result in substantial changes (either positive or negative) in overall voice production and quality. Additionally, individual variability denotes that some people are intrinsically pre-disposed to vibration overdose while others will be hypo-responsive to a given intervention (Roy, 2012).

Second are challenges related to environmental and client-specific factors as discussed by Roy (2012). External variables such as motivation, time commitment, financial resources, and family support may contribute to feasibility of a given intervention. These person-specific factors may contribute to reduced or enhanced treatment fidelity in the clinical setting, where VFEs are often used in combination with other interventions and modified for the individual client. This practice prevents replication of intervention provided in randomised controlled trials, and the effects of combining treatments remains an open question (Roy, 2012). Client-specific factors such as self-efficacy, organisation, buy-in, prior experience, and stress levels also have important implications for patient compliance, or adherence to a pattern of treatment, which will affect overall therapeutic outcome.

Third, the terms dose, dosage, intensity, and other related terminology are not consistently defined in the literature and are often multifaceted or overlapping. For example, Baker (2012) discusses in detail the nuances associated with the term dosage, including the number and duration of sessions, overall length of intervention, density of teaching episodes, number of client responses, and frequency of independent practice. Baker (2012) also underscores the idea that since behavioural interventions are not only affected by quantity but by quality, clinician competence and treatment fidelity are also critical factors in determining treatment outcomes and may ultimately influence the required quantity of intervention.

It is beyond the scope of this paper to define and differentiate the numerous terms used to describe treatment quantity. Mention of the varied terminology surrounding treatment quantity serves to illustrate the complexity and disagreement surrounding the topic of measuring behavioural intervention. For the purpose of this study and related discussion, we have chosen to define dose and dosage because they are interdependent and critical to understanding the independent variable in this study's design. Dose is defined as a specific quantity of a therapeutic agent administered at a point in time. For example, 500 mg of an antibiotic taken for strep throat is a dose, as it represents a specific quantity of a medicine delivered at once. As previously discussed, for many behavioural interventions like VFEs, dose is difficult to define because the active ingredient(s) responsible for physiologic change is/are unknown. In other words, it is not clear whether some elements within VFEs are responsible for improvements in voice production while other elements are superfluous, or whether the entire protocol is essential to efficacy. Bearing this limitation in mind, a single dose of VFEs is defined here as a single set of four exercises consisting of the warm up, stretching, contracting, and low-impact power adductory exercise described by Stemple et al. (1994) and Roy et al. (2001). In this study, VFE dose remained constant for all groups.

Dosage, although frequently used interchangeably with the word dose, refers to the frequency of a dose administered over time. For example, the 500 mg antibiotic given three times daily for 10 days now includes the dosage. Thus, dosage refers to the concept of repeated exposures or applications of a certain dose, and therefore implies cumulative intervention. For behavioural interventions, dosage can be multifaceted as illustrated by Baker (2012). As defined in this study, VFE dosage includes the number of repetitions of each exercise, the frequency of the exercise set, and the overall length of intervention. Frequency and overall length of intervention aspects of dosage remained constant for all groups in this study; all participants completed VFEs twice daily (morning and evening) for six weeks. The modified element was the exercise repetition aspect of dosage. Traditionally, VFEs require two repetitions of all four exercises; this study doubled and halved the required number of repetitions to compare three distinct dosages. We chose to modify only a single aspect of VFE dosage to determine its precise contribution to treatment efficacy.

Prior to initiation of this study, some conclusions related to dosage could be drawn from studies whose methodologies resulted in reduced exposure to VFEs secondary to compliance level, group service delivery model, or modification of the exercise protocol. The term exposure is used here in place of dosage since none of these studies explicitly or consistently manipulated dosage; however, the study method in some way changed the recommended amount of intervention or practice provided. Based on these studies, a few inferences were made: a) lower exposure to VFEs may be sufficient to improve the normal voice (Ellis & Beltyukova, 2011); b) lower exposure to VFEs may not improve the normal voice to the same extent that a higher exposure would (Ellis & Beltyukova, 2011); c) lower exposure to VFEs may be insufficient to improve the disordered voice (Pasa et al., 2007); d) traditional exposure to VFEs with modified technique may be sufficient to improve the disordered voice (Radhakrishnan & Scheidt, 2012).

Some information could also be gleaned from research exploring dosage in other types of voice interventions, such as therapies based on the Lee Silverman Voice Treatment (LSVT)®

(Ramig, Countryman, Thompson, & Horri, 1995). Additionally, some efforts have been made to investigate varying quantities of post-surgical voice rest; however, voice rest remains a controversial subject and there has been little agreement as to how much voice rest is ideal for surgical recovery (Roy, 2012). Still other studies have examined varying voice therapy service delivery models. Based on these studies, a few inferences can be made: a) there is literature to support intense treatment in terms of efficiency, improved outcomes, compliance, patient satisfaction, neuroplasticity and maintenance (Classen, Liepert, Wise, Hallett, & Cohen, 1998; Dayan & Cohen, 2011; Patel, Bless, & Thibeault, 2011; Spielman, Ramig, Mahler, Halpern, & Gavin, 2007; Verdolini-Marston, Burke, Lessac, Glaze, & Caldwell, 1995; Wenke et al., 2014); b) efficacy of treatment is dependent not only upon quantity or intensity but also on active therapeutic ingredients (Baker, 2012; Baumgartner, Sapir, & Ramig, 2001; Ramig et al., 1995; Ramig, Countryman, O'Brien, Hoehn, & Thompson, 1996); c) dose, dosage, and intensity have not been systematically differentiated or studied (Roy, 2012); d) toxic effects of intense voice treatment have not yet been defined in the literature (Roy, 2012).

Based on the literature, there is little consensus regarding optimal quantity, dosage and intensity of voice therapies. No research has explicitly examined dosage as it applies to VFEs. The primary purpose of this study was to investigate whether increased VFE repetitions during at-home practice resulted in greater increase in maximum phonation time (MPT). A secondary purpose was to observe the presence or absence of toxic effects on the vocal folds secondary to high dosage VFE home practice. More broadly, the overarching goal of this study was to contribute to a dosage-response curve that would describe the number of VFE repetitions necessary for optimising outcomes in normal voice.

Method

Participants

All recruitment, intervention, and data collection procedures were approved by the Institutional Review Board at the University of Kentucky. A total of 28 participants completed the study and met the following inclusion criteria: female, ages 18–25, non-smokers, and hearing within functional limits. Sex and age requirements were set to be consistent with the use of a convenience sample of University students. Functional hearing was defined as the participant's ability to participate in experimental tasks, imitate vocal exercises and adapt to feedback in ambient space. A year or more of classical vocal training, history of uncontrolled asthma, and presence of vocal fold pathology identified by laryngeal visualisation constituted exclusion from the investigation. Vocal fold pathology was defined as any visible mass lesion, erythema or oedema. We reiterate that study participants were individuals with normal voice, a population chosen due to the paucity of research related to dosage-response for VFEs. Furthermore, VFEs were established in the normal voice, and since individuals do not work optimally to produce voice, normal voice can be expected to improve in response to exercise (Stemple et al., 1994; Stemple, Roy, & Klaben, 2014).

Study protocol

Participants were randomised into one of three experimental groups: low ($n = 9$), traditional ($n = 9$) or high dosage ($n = 10$). After informed consent was obtained, all participants were educated on harmful vocal behaviours and verbally agreed to abstain from these during the study period; however, compliance with avoiding vocally harmful behaviours was not monitored. Baseline data were obtained, which included visual-perceptual/stroboscopic observation, Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) score (Kempster, Gerratt, Verdolini Abbott, Barkmeier-Kraemer, & Hillman, 2009), Voice-Related Quality of Life (VRQOL) score (Hogikyan & Sethuraman, 1999), and maximum airflow volume (MAV). MAV refers to the maximum volume of air that can be exhaled after a maximum inhalation. To determine normalcy for inclusion in the study, stroboscopic observations were completed by four certified and licenced speech-language pathologists with expertise in voice using a KayPENTAX High-Definition Digital Stroboscopy System 9310HD. Normalcy was determined using a binary classification of abnormal/normal. In cases of unusual findings such as mass lesion, oedema, or erythema, a second speech-language pathologist with experience in stroboscopy also viewed the images for consensus. The V-RQOL, a self-assessment of voice production, demonstrated normal self-assessed vocal quality. The CAPE-V, an auditory-perceptual evaluation of voice, was completed by a speech-language pathologist and confirmed normalcy of perceived voice quality. MAV was determined using the KayPENTAX Phonatory Aerodynamic System 6600 and divided by a standard airflow rate of 80 mL/s to calculate an individual MPT goal in seconds (e.g. 4000 mL/80 mL/s = 50 s). This MPT goal calculation was recommended by Stemple & Hapner (2014) for use when completing the VFE protocol. The denominator of 80 mL/s approximates the lower end of normal airflow rate (70–200 mL/s) described by Hirano (1981). This MPT is intended to represent the individual's physiologic limit for maximum phonation and is measured in seconds.

After baseline data collection, participants met with a research assistant to learn the VFE protocol as described by Stemple et al. (1994). Research assistants were six undergraduate students in Communication Sciences and Disorders with no prior experience with voice therapy techniques. All research assistants received group and individual trainings by a speech-language pathologist with expertise in voice disorders. Once each study participant had learned VFEs from a research assistant, a speech-language pathologist and expert in voice joined the session to solidify technique and obtain MPT baselines. In this study, the primary outcome measure of MPT was always collected during VFEs in the semi-occluded vocal tract (SOVT) posture described by Stemple et al. (1994). This SOVT posture is formed by expanding the pharynx and creating a narrow labial aperture on the speech sound /o/.

After establishing baseline MPT, participants were given practice log sheets and a practice video specific to their dosage group. The practice video consisted of a female speech-language pathologist completing VFEs once, twice or four times depending on the participant's assigned dosage. The video provided brief verbal instructions describing the upcoming exercise, the appropriate musical pitch, and a video of the clinician completing the exercise. The format was such that the participant could complete practice along with the video and have a visual and aural example.

All three experimental groups practiced VFEs twice daily, once in the morning and once in the evening, seven days per week for six weeks. Participants received reminders to practice via email twice a day. The low dosage group practiced all exercises once each, twice daily, the traditional dosage group performed all exercises two times each, twice daily, and the high dosage group completed all exercises four times each, twice daily. Participants returned weekly for practice sessions with research assistants, who administered the V-RQOL, recorded MPTs, adjusted technique with the help of a supervising clinician, and collected record sheets to track task compliance. Weekly sessions with the research assistants counted as one of the practices for the day. Therefore, participants in the low dosage group completed each exercise once during the session, those in the traditional dosage group completed each exercise twice, and those in the high dosage group did each exercise four times. A speech-language pathologist with expertise in voice monitored 20% of all research assistant-conducted sessions with study participants, and a second year graduate student with experience using VFEs monitored an additional 20% of sessions.

To monitor for potential toxicity, which was defined as visualisation of any mass lesion, erythema or oedema, participants underwent laryngeal visualisation after three weeks of exercises. After six weeks of VFEs, laryngeal visualisation was repeated a third time, MPT was collected, and home practice and weekly practice sessions with research assistants were discontinued. Participants returned four weeks later for follow-up and MPT was obtained for each participant. Laryngeal visualisation was not repeated one month after VFE since the primary rationale for visualisation of the vocal folds was to verify presence or absence of detrimental effects to the laryngeal mechanism as a result of VFEs, and participants had discontinued exercise after six weeks. Similar to baseline data collection, all stroboscopic observations were completed by four voice-specialised speech-language pathologists who were blinded to group assignment. Laryngeal visualisations were simply binary, characterised as normal or abnormal, and depended upon the expert opinion of the experienced speech-language pathologist.

Participants who withdrew their participation were asked to complete a questionnaire regarding their rationale for discontinuing the study. The questionnaire first asked participants to indicate how difficult or uncomfortable their stroboscopic observation was (mild, moderate or extreme). The second question asked participants to indicate all applicable reasons for withdrawal of participation (exercise-related fatigue or pain, difficulty achieving exercise technique, time commitment, personal matter, chose not to provide a reason or other).

Data analysis

To ensure equivalency of groups at baseline, assumptions were verified and a one-way ANOVA was completed for age and initial MPT. Since MPT capability varies individually due to variation in MAV, MPT was standardised across subjects by calculating percentage of goal attained. For example, a person with a 50 s MPT goal and a baseline MPT of 25 s was said to have attained 50% of their MPT goal at baseline.

For the primary outcome measure of MPT, ANOVAs with a Greenhouse–Geisser correction were used to test whether MPT was significantly different between groups and to test

whether there was a significant time effect, indicating whether groups changed over time. For outcome measures with significant interactions, paired sample t-tests with a Bonferroni correction were used to examine post-hoc within groups effects and independent sample t-tests with a Bonferroni correction were used to analyse between groups effects. Hedges' g effect sizes were calculated to compare low dosage to traditional dosage and high dosage to traditional dosage.

Compliance from practice log sheets was tabulated after the study to determine number of practice sessions missed. Missed practice sessions did not result in missing data points, since all baseline, three-week, six-week, and one-month follow-up measures were collected during visits for practice sessions with research assistants. Tabulation of missed practices allowed for descriptive comparison of compliance among dosage groups.

Result

Group homogeneity at baseline was determined for age and initial MPT; differences between groups were not significant. Time and time by group interactions were significant within groups, indicating groups changed over time but in different ways (Table I). Within groups analyses demonstrated that in the low dosage group, change in MPT was not statistically significant over time. In the traditional dosage group, MPT significantly changed after six weeks of VFEs. In the high dosage group, MPT significantly changed after six weeks of VFEs and remained significantly changed at one-month follow-up after discontinuation of practice (Table II). Between groups analyses of MPT demonstrated a significantly higher MPT in the traditional dosage group compared to the low dosage group after six weeks of VFEs (Table III). Many participants did not attain their MPT goal within the six-week study period; however, the central concern of this study was not whether individuals attained goal. Rather, our interest was in how much participants were able to increase their MPT within the time allotted, given a specific dosage.

An effect size of 1.51 was obtained for the low and traditional dosage groups, indicating a large negative effect of low dosage on MPT compared to traditional dosage. An effect size of 0.31 was obtained for the high and traditional dosage groups, indicating a small positive effect of high dosage on MPT compared to traditional dosage (Table IV).

Toxicity

Toxicity was defined as visualisation of any mass lesion, erythema or oedema. No obvious toxic effects to the vocal fold mucosa were observed in any of the intervention groups as visually and subjectively assessed using stroboscopy or through the use of a participant self-assessment scale (V-RQOL). One of the participants who withdrew from the study had been assigned to the high dosage group and complained of vocal fatigue and throat soreness, but declined laryngeal visualisation. There were other participants who discontinued the study, but none complained of fatigue or pain secondary to VFEs.

Compliance

Participant compliance with weekly sessions was 99%. The median number of missed practice sessions was one in the low dosage group, zero in the traditional dosage group, and

one in the high dosage group. Two participants in the low dosage group, one in the traditional dosage group, and two in the high dosage group missed five or more practice sessions. Over the course of the study, a number of participants withdrew their participation. Withdrawal rates were 22, 11, and 50% in the low, traditional, and high dosage groups, respectively. Subjects who withdrew from the study were replaced by new recruits, all of whom completed the study protocol. All subjects who withdrew did so in the first week and only provided baseline data. Therefore, they were not included in the results of this study.

Upon discontinuation of this study, participants were asked to complete a questionnaire regarding rationale for withdrawal. Six of the eight withdrawn participants responded, and results indicated that discomfort secondary to laryngeal visualisation was only a complaint for one participant. Five former participants reported excessive time commitment led to their discontinuation. Three of those who reported excessive time commitment had been placed in the high dosage group. Two reported difficulty mastering the required technique for VFEs, one of whom belonged to the traditional dosage group and one of whom had been assigned to the high dosage group.

Discussion

Low dosage VFEs failed to improve MPT significantly, while traditional and high dosage VFEs significantly improved MPT. The high dosage group improved MPT the greatest amount and continued to demonstrate significantly increased MPT one month after VFE completion. The findings of this study can best be summarised visually (Figure 1). The figure demonstrates improvement from baseline for all three experimental groups, with greatest improvement in the high dosage group. Decline in MPT at one-month follow-up represents reduction in MPT with practice cessation for all three groups, though none of the three groups returned to baseline function.

The benefits of high dosage VFEs should be weighed against the 50% participant withdrawal rate associated with increased dosage. Given the importance of compliance in voice therapy, increasing dosage may undermine one of many key components of the programme and reduce its effectiveness. Interestingly, low dosage also elicited poorer compliance. Out of the three groups, the traditional dosage group exhibited superior compliance and lowest percentage of withdrawn participants. It is possible that, for the low dosage group, fewer repetitions during practice led to longer amounts of time spent in the pre-learning stage, where technique is not yet consolidated (Wenke et al., 2014). Failure to consolidate technique may have reduced motivation as well as compliance in the low dosage group. In the high dosage group, increased repetitions during home practice may have been overwhelming to participants or simply too much to ask, potentially explaining the high withdrawal rate. It may be that twice is a reasonable expectation for exercise repetition, a number that most people feel is achievable and sufficient in terms of practice. Thus, non-compliance may be the result of a variety of issues. Reduced practice may undermine motor learning, increase frustration, and reduce motivation (Classen et al., 1998; Shumway-Cook & Woollacott, 2012). Increased practice may make the task overwhelming in terms of time and effort, or even fatiguing. Those who do not have time to complete four repetitions may

be more likely to skip the exercise session altogether, rather than completing at least some of the exercise.

Limitations and future directions

This study contains certain limitations. First, compliance with home practice was self-reported and could not be verified by the researcher. Certain aspects of this study's methodology were included specifically to address this limitation: compliance was stressed to all participants; videos were provided to guide practice; participants received practice reminder emails; logs were kept and returned weekly. Second, research assistants provided guidance for weekly sessions. It is well understood that the clinical expertise of an experienced speech-language pathologist has important implications for successful intervention. Research assistants with limited experience in voice therapy techniques are not likely to be as motivating, knowledgeable, or responsive as experienced speech-language pathologists. This limitation was addressed by several aspects of the study's design: research assistants received training from a speech-language pathologist and expert in voice; experienced clinicians verified VFE technique with each participant; 20% of all weekly sessions were supervised by experienced voice clinicians, and an additional 20% were monitored by a second year graduate student.

This investigation was a pilot dosage study. It is the only study to systematically examine the effects of varying VFE dosage. Further research is necessary to determine optimal dosage-response relationships for VFEs, particularly in the disordered voice. Future investigations should include larger sample sizes and a greater variety of dosage groups. Additional data such as clinician-made ratings of participant technique may be informative, as well as alternate means of compliance tracking that allow for investigator verification.

Conclusion

Higher dosage of home practice VFEs led to greater improvement in MPT. Conversely, lower dosage may have prevented improvement in MPT. Home practice of VFEs up to twice daily, four times each for up to six weeks did not result in observable mass lesion, erythema or oedema in individuals with normal voice as assessed by the use of stroboscopy and self-assessment scales. The point of toxicity for VFE dosage was not identified in this study.

In summary, low dosage VFEs may improve normal voice, though not significantly. Traditional and high dosage may produce similar gains with a slight advantage for high dosage. In this study, traditional dosage VFEs appears to have resulted in best overall compliance with practiced tasks, which has important implications for overall outcomes. Therefore, dosage may be an active ingredient in behavioural interventions that should be tailored to the individual. For example, high dosage VFEs may be feasible for select individuals, particularly for those who are highly motivated or training for specific vocal events. In instructing clients on home practice schedules, it is important to weigh client-spent effort and time against expected benefits of (extended) practice. Dosage may not be the most critical factor determining VFE efficacy, but may be one of many factors that determine overall improvement in voice production.

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Figure 1.

Percentage of maximum phonation time goal attained by time and group, with vocal function exercises (VFE).

Table I.

Effects of group and time on maximum phonation time (MPT).

Interaction	<i>F</i>	<i>p</i> Value
Between group	3.01	0.07
Within group time		
Greenhouse-Geisser	46.76	<0.01 ★
Within group time ★ Group		
Greenhouse-Geisser	3.76	0.02 ★

★ denotes significance at $p = 0.05$.

Table II.

Within groups effects of vocal function exercises (VFE) on percentage of maximum phonation time goal attained.

Group	Time comparisons	Mean	Standard deviation	p value [†]
Low <i>n</i> = 9	Pre and post	35.67	8.49	13.00
	Post and 1 mo. after VFE	46.67	13.00	17.55
	Pre and 1 mo. after VFE	35.67	8.49	17.55
Traditional <i>n</i> = 9	Pre and post	41.11	12.35	12.19
	Post and 1 mo. after VFE	66.67	12.19	13.37
	Pre and 1 mo. after VFE	41.11	12.35	13.37
High <i>n</i> = 10	Pre and post	40.30	73.60	57.60
	Post and 1 mo. after VFE	73.60	57.60	27.35
	Pre and 1 mo. after VFE	40.30	57.60	17.35

[†] Paired samples t-tests.

★ denotes significance at *p* 0.0056; mo.= month.

Table III.

Between groups effects for percentage of maximum phonation time goal attained.

Time	Group comparisons	Mean	Standard deviation	p Value [†]
Pre	Low and traditional	35.67	41.11	8.49
	Traditional and high	41.11	40.30	12.35
	Low and high	35.67	40.30	8.49
Post	Low and traditional	46.67	66.67	13.00
	Traditional and high	66.67	73.60	12.19
	Low and high	46.67	73.60	13.00
One month after VFE	Low and traditional	44.89	55.78	17.55
	Traditional and high	55.78	57.60	13.36
	Low and high	44.89	57.60	17.55

[†]Independent samples t-tests; VFE: vocal function exercises.★ denotes significance at $p = 0.0056$.

Table IV.

Within groups effect sizes for percentage of maximum phonation time goal attained.

Comparison	Effect size (Hedges' g)	95% Confidence interval
Low-traditional	- 1.51 (large)	[-2.56, -0.46]
High-traditional	0.31 (small)	[-0.60, 1.21]

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